

CHEMISTRY 101
Hour Exam III
April 25, 2024
Dr. E. McCarren

Name _____

Signature _____

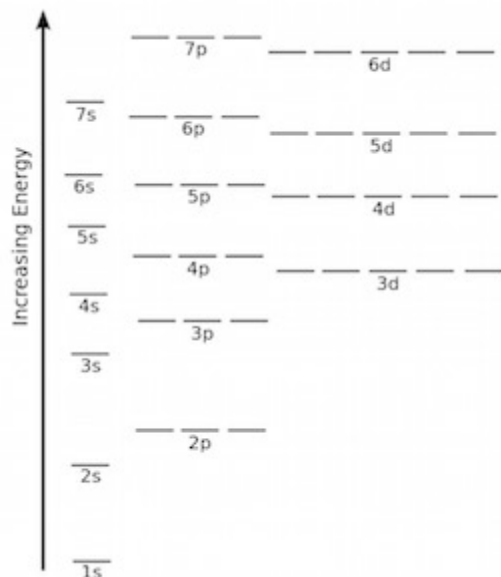
Section _____

“The big talent is persistence.” – Octavia E. Butler, American author

This exam contains 17 questions on 9 numbered pages. **Check now** to make sure you have a complete exam. You have one hour and thirty minutes to complete the exam. Determine the best answer to the first 15 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. Show all of your work and provide complete answers to questions 16 and 17.

| | | |
|-------|-----------|-------|
| 1-15 | (30 pts.) | _____ |
| 16 | (12 pts.) | _____ |
| 17 | (18 pts.) | _____ |
| Total | (60 pts) | _____ |

Useful information:



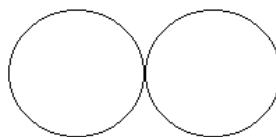
Part 1: Multiple Choice

1. Which of the following processes is **endothermic**? The system is underlined in each case.
- A racquetball hardens in liquid nitrogen.
 - Natural gas is burned in a furnace.
 - Ice melts on a warm day.
 - Sulfuric acid is added to a solution and the solution gets very hot.
 - Gaseous water vapor condenses into liquid water.

2. Which of the following is **true** related to exothermic processes?

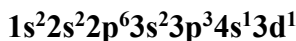
In an exothermic process...

- the products have higher energy than the reactants.
 - energy is transferred into the system
 - the surroundings lose heat from the system.
 - the products are more stable than the reactants.
 - activation energy is not needed to start a reaction.
3. Which of the following is still considered to be **true** related to our understanding of atomic structure?
- Atoms are the smallest possible indivisible particles.
 - Negatively charged electrons orbit the center of an atom on circular paths.
 - An atom contains a positively charged cloud which holds electrons.
 - All atoms of a single element are identical to one another.
 - The outer electrons of an atom are most likely to participate in bond formation.
4. The following diagram displays a p orbital similar to those that we have discussed in class. Which of the following is **true** related to this p orbital?



- This p orbital can hold six electrons.
- Electrons are in either the left side or right side of the orbital at any given time.
- Electrons move along the surface of the area designated by the orbital.
- Electrons may be located either inside or outside the area designated by the p orbital.
- Electrons may be positively or negatively charged when they are located within the p-orbital.

5. Which of the following is the correct ground state electron configuration for a neutral atom of tellurium (#52)?
- $[\text{Kr}]5s^24d^{10}5p^4$
 - $[\text{Kr}]5s^25d^{10}5p^4$
 - $[\text{Kr}]4s^24d^{10}5p^4$
 - $[\text{Ar}]4s^23d^{10}4p^4$
 - $[\text{Ar}]5s^24d^{14}$
6. The electron configuration below is for a neutral atom in an excited state. Which of the following is true related to this electron configuration?



- This is the electron configuration for a neutral atom of scandium.
 - The atom represented by this configuration has six valence electrons overall.
 - The atom represented by this electron configuration is a halogen.
 - There are two unpaired electrons in this configuration as written.
 - The third energy level is completely full of electrons as written in this configuration.
7. Which option correctly ranks the following neutral atoms from smallest to largest atomic radius?

O F C Ne N

- $\text{Ne} < \text{F} < \text{O} < \text{N} < \text{C}$
- $\text{C} < \text{N} < \text{O} < \text{F} < \text{Ne}$
- $\text{N} < \text{O} < \text{C} < \text{Ne} < \text{F}$
- $\text{F} < \text{Ne} < \text{C} < \text{O} < \text{N}$
- $\text{O} < \text{C} < \text{F} < \text{Ne} < \text{N}$

8. Atoms are smaller near the right of a horizontal row on the periodic table and larger to the left on the periodic table. Which best explains *why* this happens?
- The atoms to the right of periodic table have a greater number of electrons which decreases atomic size.
 - There are more energy levels of electrons towards the left of the periodic table which pushes electrons further from the nucleus.
 - The atoms to the right of the periodic table have lost electrons which decreases the size of the atom.
 - The increased protons to the right of the periodic table attract the electrons more strongly.
 - Metal atoms are on the left of the periodic table which are smaller than nonmetal atoms.
9. What is a London dispersion force?
- Attractions between the positive and negative ends of separate molecules.
 - Attractions between molecules due to random movements of electrons.
 - Strong attractions between molecules which have F, O, and N atoms.
 - Attractions between cations and anions of ionic compounds.
 - Bonds within compounds which maintain the compound's internal structure.
10. Select the option which best fills in the blanks below.

For molecules of similar sizes, substances with stronger intermolecular forces are _____ likely to be found in the gas phase at room temperature and have _____ boiling points compared to substances with weaker forces.

- less; higher
 - more; higher
 - less; lower
 - more; lower
 - equally; lower
11. Which choice below best describes a polar molecule?

A polar molecule always...

- has lone pairs of electrons around the central atom.
- has one end that is more negative and another that is more positive.
- has electrons evenly distributed around the central atom.
- has atoms of only one type of element attached to the central atom.
- consists of at least one atom of hydrogen.

The five molecules listed below all contain one or more atoms of fluorine. Draw Lewis structures for these molecules and use them to answer the next several questions.



12. Which of the structures has 20 valence electrons in its Lewis structure?
- a. HF
 - b. SF₂
 - c. SF₄
 - d. IF₅
 - e. IF₃
13. Which of the structures has a T-shape?
- a. HF
 - b. SF₂
 - c. SF₄
 - d. IF₅
 - e. IF₃
14. How many of the structures have 5 effective pairs of electrons around the central atom?
- a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5 (All five structures have five effective pairs of electrons.)
15. How many of the molecules are polar?
- a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5 (All five molecules are polar.)

Please go on to the next page.

16. Each of the following statements compares the chemical properties of a pair of atoms or ions. Explain the comparisons by answering the questions below.

- a. It is harder to remove an electron from a neutral atom of sodium (Na) than a neutral atom of rubidium (Rb). Why is this? Explain. Your explanation should include the reasoning behind this ionization energy trend at an atomic level (addressing protons, electrons, and energy levels), and should go beyond simply stating the trend.
- b. A neutral atom of sulfur (S) has smaller radius than the most stable ion of sulfur (S^{2-}). Why is this? Explain. Your explanation should include the following:
- The number of protons in each species
 - The number of electrons in each species
 - How the numbers of protons and electrons relate to size

- c. The bond formed between an atom of carbon and an atom of nitrogen ($\text{N} - \text{C}$) is less polar than the bond formed between an atom of nitrogen and an atom of hydrogen ($\text{N} - \text{H}$). Why is this? Explain. Your explanation should include the following:
- The definition of a bond
 - The definition of electronegativity
 - A comparison of electronegativity differences between the atoms in each of the bonds
 - How electronegativity differences relate to bond polarity

Please go on to the next page.

17. Consider each of the following pairs of molecules. The two molecules in each pair all have the **same molecular shape**. For each of the molecules, draw the correct Lewis structure and use the Lewis structure to determine the shape, polarity, and strongest intermolecular forces present between molecules of each substance. Then, identify the molecule in each pair which has a higher boiling point. Note: you do not need to draw multiple resonance structures if a molecule displays resonance. You only need to draw one possible structure.

Pair 1

| Molecule | Lewis Structure | Shape | Polar or nonpolar? | Strongest Intermolecular Forces |
|--|-----------------|-------|--------------------|---------------------------------|
| CO ₂ | | | | |
| HCN | | | | |
| The substance with the higher boiling point in this pair is _____. | | | | |

Pair 2

| Molecule | Lewis Structure | Shape | Polar or nonpolar? | Strongest Intermolecular Forces |
|--|-----------------|-------|--------------------|---------------------------------|
| NH ₃ | | | | |
| PH ₃ | | | | |
| The substance with the higher boiling point in this pair is _____. | | | | |

Pair 3

| Molecule | Lewis Structure | Shape | Polar or nonpolar? | Strongest Intermolecular Forces |
|--|------------------------|--------------|---------------------------|--|
| CH₄ | | | | |
| CH₂Cl₂ | | | | |
| The substance with the higher boiling point in this pair is _____. | | | | |

Pair 4

| Molecule | Lewis Structure | Shape | Polar or nonpolar? | Strongest Intermolecular Forces |
|--|------------------------|--------------|---------------------------|--|
| XeCl₄ | | | | |
| XeF₄ | | | | |
| The substance with the higher boiling point in this pair is _____. | | | | |

Stop.

You have reached the end of the exam. Nothing written after this page will be graded.